Topology-finding of Tensegrity Structures Considering Stability Condition

Yafeng WANG[a], Xian XU*, Yaozhi LUO[a]

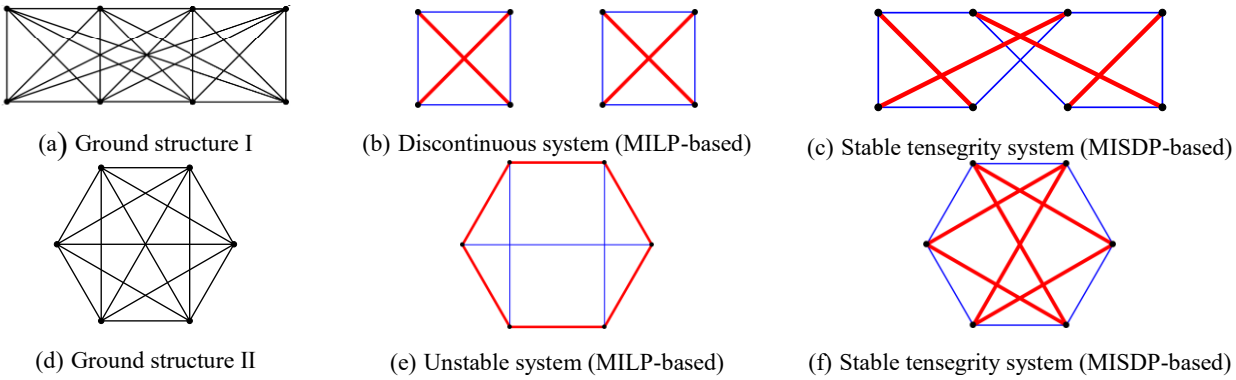
* Department of Civil Engineering, Zhejiang University
A-725 Anzhong Building, 866Yuhangtang Road, Hangzhou, Zhejiang, China
xian_xu@zju.edu.cn
[a] Department of Civil Engineering, Zhejiang University

Abstract

Topology-finding of tensegrity structures has become an attractive topic in recent years because its significance for the application of tensegrity structures in real engineering areas. Among all the proposed approaches, mixed integer linear programming (MILP) based method is the most effective one. The MILP-based approach for topology-finding of tensegrity structures was firstly proposed by Ehara and Kanno in 2010 [1] and then extended by Kanno [2] and Xu et al. [3]. Although many more meaningful and practical constraints such as member length constraint, member force evenness constraint etc. have been taken into consideration in the extended works, a critical problem in the MILP-based approach has not been solved yet. That is, the stability issue.

Stability condition of tensegrity structures is a nonlinear formulation involving the positive definiteness of matrix which cannot be considered in a MILP framework. Thus, a post-check procedure is used in a MILP-based topology-finding approach to check the stability of the found system. Because of the missing of stability condition in the MILP-based framework, two problems may arise in the process of topology-finding of tensegrity structures: 1) the found system may be discontinuous, as shown in Fig. 1b; and 2) the found system may be unstable, as shown in Fig. 1e.

In order to avoid these two kinds of undesirable results, the stability condition of tensegrity structures needs to be considered in the process of topology-finding. In this paper, the MILP-based approach is improved and transformed to a new mixed integer semi-definite programming (MISDP) based approach which takes the stability condition of tensegrity structures into consideration. By using this new MISDP-based scheme, not only the two undesirable phenomena described above can be totally avoided but also different stability conditions (general stability, prestress stability and super stability) can be constrained into the topology-finding process. Brach-and-bound framework combined with interior point algorithm is used to solve the MISDPs. Some examples are given to demonstrate the improvements and effectiveness of the proposed MISDP scheme.



(a) Ground structure I (b) Discontinuous system (MILP-based) (c) Stable tensegrity system (MISDP-based)

(d) Ground structure II (e) Unstable system (MILP-based) (f) Stable tensegrity system (MISDP-based)

Figure 1 Different systems found by using MILP- and MISDP-based approach

References

[1] S. Ehara and Y. Kanno, "Topology design of tensegrity structures via mixed integer programming," *International Journal of Solids and Structures*, vol. 47, pp. 571--579, 2010.
[2] Y. Kanno, "Exploring new tensegrity structures via mixed integer programming," *Structural and Multidisciplinary Optimization*, vol. 48, pp. 95--114, 2013.
[3] X. Xu, Y. Wang and Y. Luo, "General approach for topology-finding of tensegrity structures," *Journal of Structural Engineering*, vol. 142, p. 04016061, 2016.